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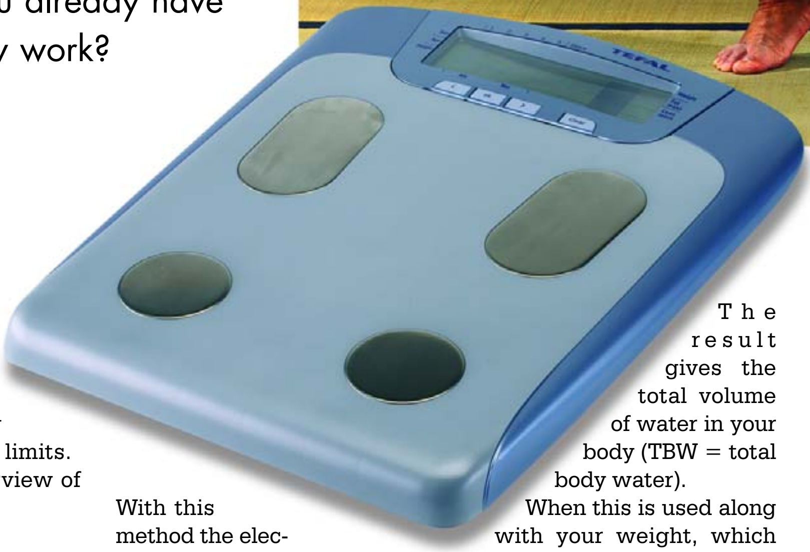
# READY, STEADY, FATTY

## Body Fat Monitor Scales

iSensible people look after their health: no smoking, moderate drinking, regular exercise and a healthy diet. And of course you want to keep an eye on your condition, for example with scales that also show your body fat percentage. Perhaps you already have one of these at home, but how do they work?



It wasn't that long ago when the body weight was the most important quantity when we looked to see if we were overweight. These days your body fat percentage is considered to give a better indication of your overall health. It tells you something about the chances of developing certain illnesses when you are too fat, such as heart and circulatory diseases, certain types of cancer and type-2 diabetes. Too little fat can also give rise to problems, especially in women. It can affect the menstruation and there is a greater chance of developing osteoporosis (calcium deficiency in bones).

It is generally accepted that it is sensible to keep your percentage body fat within certain limits. **Table 1** gives an overview of the ideal values.

### Determining the body fat percentage

Good electronic scales use the so-called bioelectrical impedance analysis (BIA) to calculate your body fat percentage. With this method the electrical impedance $Z$ of the body is measured. This is put into a formula along with the length of the 'conductor', $l$, (in this case your body) and the resistivity of body tissue ρ:

$$TBW = \rho \times l / Z$$

The result gives the total volume of water in your body (TBW = total body water).

When this is used along with your weight, which was measured at the same time, a good estimate can be made of your body fat percentage.

This method is widely used in the medical world and normally uses electrodes on leads,

### How to obtain the best results

You should first go to a specialist for an accurate body fat measurement. This result can then be used to estimate how accurate your body fat monitor scales are. There is little point in comparing your score with that of others. You should only use the body fat monitor to observe any changes. The following guidelines will help keep any possible measurement errors as small (and constant) as possible:

- Take the measurement at a fixed time of the day.
- Take the measurement at the same ambient temperature, as the temperature of the skin affects its conductivity.
- Make sure that your feet are clean and dry. For the best result you should use alcohol.
- One hour before every measurement you should drink an identical amount of water.
- Don't take a measurement directly after exercise. The perspiration causes a loss of body fluids, which affects the measurement.

| | 18-30 years | 31-40 years | > 40 years |
|---|---|---|---|
| **Men** | 15 % | 17,5 % | 20 to 25 % |
| **Women** | 25 % | 27,5 % | 30 to 35 % |

*Table 1. Ideal body fat percentage for different age groups and gender.*

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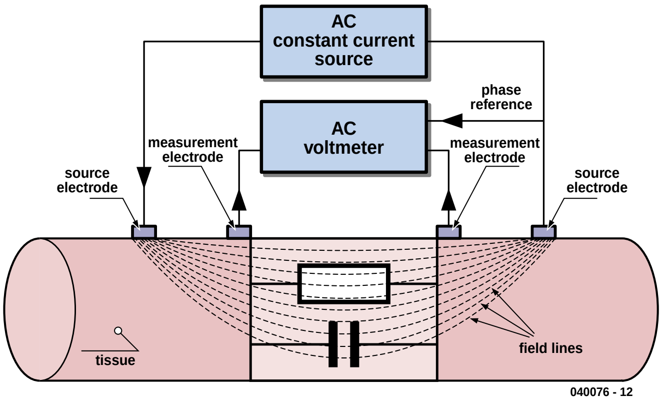

*Figure 1. The impedance is measured using a constant current AC source and four electrodes.*

which are connected to the wrist and ankle, causing the alternating measurement current to flow through the whole body. On body fat monitor scales for use in the home we have to make do with fixed electrodes, which are underneath the feet.

## Operation

BIA is based on the difference in conductivity between fatty and lean tissue in the body. A constant alternating current is fed through the body via two electrodes, with one placed underneath each foot. Typical values are about 800 µA and 50 kHz. The resulting voltage is measured using two different electrodes, also placed underneath the feet (**Figure 1**). This then allows us to calculate the impedance of the body.

The impedance of lean tissue, which contains the most intracellular fluids and electrolytes, is lower than that of fatty tissue. The measured impedance therefore gives an indication of the total volume of water in the body. An estimate of the total quantity of lean tissue can now be made with the help of several standardised formulae. The amount of fatty tissue is then calculated by subtracting the weight of lean tissue from the total body weight.

## Better accuracy

A more accurate result can be achieved when you take into account that tissue consists of a combination of resistive and capacitive conductors (**Figure 2**). The fluids inside the body provide the resistive part of the impedance, whereas cell membranes have a capacitive effect. Fat cells don't have cell membranes, so they don't contribute to the capacitive part of the impedance.

When a wide-band signal is used to measure the impedance over a larger frequency spectrum, a better distinction can be made between the contribution of extracellular fluid (low frequencies) and the impedance of all fluids (higher frequencies). This method is often called 'multi-frequency BIA'. The Tefal scales that we looked at in the lab also operates according to this principle.

## Dependability

Although the BIA method is based on known physical phenomena, a few question marks remain about its dependability. For example, it assumes that the body can be represented by a uniform cylinder filled with tissues. You don't have to be an expert to see that this is not the case.
In general we can assume that a simple setup (with electrodes only connected to the feet), which is used in uncontrolled conditions (as far as temperature, hydration and orientation of the body are concerned), is unsuitable for taking absolute measurements.

Scales with a (multi-frequency) BIA *can* be used to keep track of *changes* in the body fat percentage over the long term. More so when several ground rules are followed when taking the measurements (see inset).

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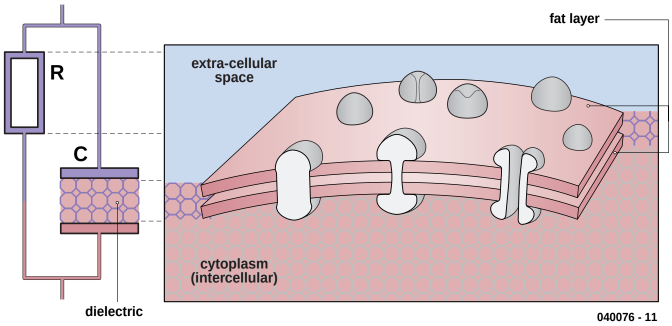

*Figure 2. Body tissue can be represented by an RC equivalent.*